

TOPEX Altimeter Range Stability Estimate Update
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Range bias changes for the NASA radar altimeter of the TOPEX/POSEIDON mission were described in the article "TOPEX Altimeter Range Stability Estimates from Calibration Mode Data", by G.S. Hayne, D.W. Hancock III, and C.L. Purdy, in TOPEX/POSEIDON Research News, JPL 410-42, Issue 3, pp. 18-22, October 1994. Reported here are the additional bias change results to date. See the October 1994 article for a further description of the measurements and methods.

Table 1 below lists values for the combined (Ku and C) delta range, in millimeters, with the same sign convention used in the October 1994 article. We changed Table 1 as of February 1996, so that it now contains bias change results both with and without a temperature correction. Prior to February 1996, the versions of Table 1 contained only the temperature-corrected results. The temperature correction reduces the standard deviations of the cycle averages and smooths out the trend of cycle averages of combined delta range, but the overall trend is about the same with or without the temperature correction. For our own instrument science interests it is appropriate to examine and to report the combined range bias changes after the temperature correction. But for the TOPEX GDR data user who does not have access to the temperature data, it is more appropriate to use the combined delta range results NOT corrected for temperature. We now provide both the uncorrected and the temperature-corrected combined delta range results in Table 1 below.

Temperatures are measured at about two dozen different positions within the TOPEX altimeter. All these temperatures move up and down together, and it is not possible to determine which of these temperatures is the most important to range bias. Our analyses use the temperature of the upconverter/frequency multiplier (UCFM) unit, and this temperature will be designated as Tu in the following. There is a correlation of the individual delta range measurement with Tu, and we have found a simple quadratic correction of the delta range for Tu variation. Using the individual delta range estimates from calibration mode 1 step 5 together with the Tu data for cycles 10-87, we have used simple least-squares fitting to find that an additive delta range adjustment Da in millimeters is approximately

$$Da = -1.817*(Tu - 25.5) - 0.073*(Tu - 25.5)^2,$$

where Tu is in degrees C and Da is in millimeters.

For the results reported in Table 1, very slightly different edit criteria were used on the calibration mode data than in the October 1994 article, and the data fit for temperature effects now includes 13 more data cycles than earlier. The result of the different fit is that the combined delta ranges in Table 1 differ from the October 1994 results, but only by about 0.05 mm. The delta range results

reported here may be valid at levels approaching a millimeter, but we think it is unrealistic to worry about differences at the sub-millimeter level.

The first column in Table 1 is the TOPEX data cycle and the second column indicates the number of individual calibrations in each cycle average. The dR_av_N is the cycle average of the combined delta range in millimeters, with NO correction for temperature, and the standard deviation estimate of the individual combined delta range (with no temperature correction) is dR_sd_N. For the temperature-corrected combined delta range, the corresponding cycle averages and standard deviations are designated dR_av_T and dR_sd_T. The cycle average for UCFM temperature in degrees centigrade is Tu_av, and the individual calibration standard deviation for this temperature is Tu_sd. Notice that the third and fourth columns of Table 1, the dR_av_N and dR_sd_N, have not been reported in earlier versions of this update work such as the October 1994 article.

A text-only (i.e., no HTML tags) version of Table 1 is available as file RngStbUp.txt, obtainable by anonymous FTP from osb.wff.nasa.gov/topex. Another way to obtain the Table 1 data is to simply click&drag to select the Table 1 columns from the Web browser's screen display, copy this selection, and then paste the values into any word processor or spreadsheet program on the browser's local host computer.

If a TOPEX GDR data user wishes to correct the GDR range data for the range calibration drift given in Table 1, this drift would be applied as

$$\text{Corrected Range} = \text{GDR range} - \text{dR_av_N}$$

Note that the Table 1 delta ranges are all given relative to a constant but arbitrary range offset, so that Table 1 will provide only a relative range drift correction.

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
001	15	+2.795	1.691	+2.003	0.645	25.086	0.834
002	18	+1.867	0.644	+1.747	0.725	25.488	0.166
003	18	+2.527	1.191	+1.792	1.085	25.143	0.239
004	18	+1.811	0.929	+1.731	0.827	25.507	0.335
005	20	+1.947	0.808	+1.611	0.680	25.368	0.207
006	20	+1.792	0.975	+2.305	0.578	25.826	0.433
007	14	+1.602	0.178	+2.104	0.625	25.823	0.331
008	18	+1.799	0.194	+1.534	0.411	25.408	0.149
009	17	+1.751	0.661	+1.437	0.524	25.378	0.282
010	20	+1.594	0.253	+1.780	0.618	25.651	0.376

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
011	20	+1.342	0.500	+2.350	0.481	26.092	0.316
012	19	+1.645	0.757	+1.978	0.614	25.732	0.332
013	15	+1.622	0.236	+1.475	0.285	25.473	0.113
014	17	+1.941	0.532	+1.181	0.592	25.129	0.227
015	19	+1.985	0.474	+1.288	0.702	25.163	0.328
016	20	+2.060	0.461	+1.772	0.511	25.393	0.266
017	21	+1.723	0.319	+2.023	0.393	25.715	0.299
018	18	+1.484	0.223	+1.867	0.394	25.761	0.202
019	16	+1.615	0.151	+1.039	0.359	25.234	0.163
021	20	+2.047	0.149	+1.713	0.336	25.368	0.236
022	20	+1.672	0.205	+1.657	0.562	25.544	0.278
023	19	+1.354	0.355	+1.505	0.341	25.635	0.246
024	21	+0.624	0.289	+1.229	0.349	25.881	0.191
025	20	+0.553	0.545	+1.454	0.439	26.031	0.462
026	19	+1.517	0.155	+1.080	0.260	25.313	0.153
027	20	+1.517	0.131	+1.019	0.287	25.278	0.165
028	20	+1.131	0.217	+1.074	0.307	25.523	0.201
029	20	+0.614	0.255	+1.040	0.486	25.784	0.241
030	18	+0.924	0.372	+0.726	0.337	25.443	0.267
032	18	+1.727	0.397	+0.882	0.209	25.079	0.291
033	17	+0.805	0.869	+0.561	0.337	25.409	0.540
034	20	+0.023	0.152	-0.126	0.491	25.471	0.242
035	18	-0.490	0.606	-0.061	0.431	25.784	0.295
036	20	-0.777	0.667	-0.181	0.461	25.876	0.189
037	18	+0.283	0.482	+0.049	0.526	25.426	0.129
038	19	+0.734	0.322	+0.622	0.250	25.491	0.268
039	20	+0.834	0.406	+0.629	0.315	25.440	0.260

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
040	21	+0.690	0.419	+0.607	0.242	25.507	0.246
042	20	-0.609	0.536	+0.224	0.422	26.002	0.185
043	19	-0.081	0.240	+0.043	0.344	25.621	0.216
044	17	+0.152	0.227	-0.027	0.370	25.455	0.169
045	20	+0.170	0.223	+0.156	0.267	25.547	0.099
046	19	-0.316	0.655	+0.208	0.514	25.837	0.212
047	19	-1.348	0.334	-0.496	0.422	26.012	0.168
048	19	-0.148	0.588	+0.136	0.375	25.707	0.268
049	18	-0.165	0.421	-0.318	0.434	25.468	0.266
050	19	+1.349	0.603	-0.001	0.309	24.789	0.255
051	20	-0.076	0.723	-0.183	0.427	25.493	0.294
052	20	-0.183	0.270	-0.398	0.344	25.436	0.122
053	20	-1.823	0.666	-1.079	0.389	25.954	0.254
054	21	-0.810	0.702	-0.609	0.310	25.661	0.269
056	20	-0.435	0.715	-0.561	0.697	25.483	0.269
057	20	-1.059	0.418	-0.691	0.448	25.752	0.285
058	20	-0.957	0.323	-1.188	0.293	25.427	0.167
059	20	-2.053	0.580	-1.487	0.450	25.860	0.194
060	20	-2.299	0.543	-1.664	0.346	25.895	0.288
061	19	-1.569	0.236	-1.709	0.307	25.477	0.155
062	20	-1.455	0.157	-1.837	0.282	25.344	0.128
063	20	-1.392	0.158	-1.864	0.294	25.293	0.124
064	21	-2.245	0.554	-1.866	0.469	25.758	0.274
066	20	-1.488	0.154	-1.910	0.221	25.321	0.131
067	19	-1.843	0.400	-2.031	0.349	25.449	0.245
068	20	-0.302	0.639	-1.938	0.390	24.621	0.261
069	20	-2.039	0.472	-1.956	0.324	25.598	0.260

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
070	20	-2.554	1.102	-2.351	0.458	25.657	0.479
071	20	-3.780	0.575	-3.011	0.456	25.968	0.197
072	20	-4.598	1.804	-3.667	1.111	26.046	0.491
073	19	-2.411	0.518	-2.456	0.281	25.528	0.236
074	20	-2.742	0.410	-2.917	0.276	25.458	0.138
075	20	-3.112	0.595	-2.958	0.292	25.637	0.239
076	19	-2.598	0.483	-2.794	0.390	25.446	0.157
077	19	-3.883	0.374	-3.314	0.407	25.862	0.192
078	20	-3.715	0.444	-3.132	0.632	25.867	0.299
080	19	-3.059	0.350	-2.809	0.308	25.690	0.157
081	20	-3.526	0.300	-3.114	0.340	25.778	0.125
082	20	-5.491	1.251	-4.348	0.960	26.163	0.283
083	20	-4.814	0.724	-3.974	0.844	26.006	0.198
084	20	-3.976	0.258	-4.118	0.322	25.476	0.137
085	20	-3.276	1.038	-3.712	0.418	25.304	0.512
086	20	-1.596	1.172	-2.628	0.637	24.970	0.384
087	20	-4.199	0.212	-3.843	0.433	25.746	0.282
088	21	-4.296	0.252	-3.827	0.502	25.808	0.216
089	20	-4.434	0.327	-3.561	0.493	26.023	0.194
090	20	-4.181	0.262	-3.921	0.625	25.691	0.393
092	20	-3.337	0.855	-2.838	0.681	25.824	0.202
093	20	-3.732	0.244	-3.631	0.540	25.608	0.236
094	20	-3.918	0.273	-3.481	0.422	25.791	0.205
095	20	-4.374	0.294	-3.650	0.486	25.945	0.143
096	19	-4.268	0.248	-4.079	0.502	25.656	0.240
098	19	-3.373	0.152	-3.689	0.297	25.379	0.142
099	20	-3.528	0.161	-3.660	0.408	25.481	0.176

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
100	19	-3.759	1.072	-3.452	0.572	25.714	0.468
101	20	-4.003	0.232	-3.706	0.551	25.714	0.265
102	20	-3.895	0.161	-4.137	0.408	25.420	0.217
104	20	-2.646	1.185	-3.306	0.504	25.177	0.545
105	20	-3.457	0.213	-3.126	0.497	25.732	0.276
106	20	-3.779	0.499	-3.170	0.592	25.882	0.229
107	20	-4.509	0.207	-3.579	0.481	26.053	0.244
108	19	-3.955	0.196	-3.961	0.352	25.551	0.177
109	19	-3.808	0.168	-3.531	0.415	25.704	0.240
110	20	-3.705	0.252	-3.311	0.296	25.769	0.152
111	20	-3.727	0.143	-3.807	0.260	25.511	0.149
112	20	-4.028	0.351	-3.418	0.255	25.884	0.173
113	20	-4.251	0.202	-3.275	0.277	26.078	0.174
115	17	-3.092	0.336	-2.734	0.321	25.748	0.167
116	20	-3.045	0.295	-2.779	0.391	25.699	0.127
117 a	16	-3.191	0.299	-2.586	0.430	25.881	0.194
119	17	-5.211	1.013	-3.527	0.925	26.438	0.482
120	20	-4.668	0.454	-4.420	0.593	25.689	0.207
121	19	-3.735	0.675	-4.940	0.315	24.869	0.430
122	20	-4.013	0.622	-4.076	0.563	25.509	0.556
123 b	13	-4.242	0.658	-4.225	0.524	25.559	0.348
124	20	-4.758	0.797	-3.166	1.176	26.394	0.359
125	21	-4.860	0.574	-3.307	0.712	26.376	0.280
127	19	-3.726	0.617	-2.929	0.385	25.981	0.315
128	20	-3.983	0.310	-3.239	0.384	25.954	0.279
129	20	-3.722	0.214	-3.439	0.352	25.708	0.206
130	20	-4.125	0.783	-3.060	0.693	26.123	0.279

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
131	20	-2.970	0.615	-2.191	0.512	25.973	0.243
132	19	-2.120	0.172	-2.254	0.321	25.481	0.122
133	20	-1.948	0.127	-2.096	0.296	25.473	0.129
134	20	-1.764	0.184	-2.089	0.323	25.375	0.118
135	20	-2.604	0.710	-2.016	0.347	25.870	0.297
136	20	-2.878	0.371	-2.320	0.344	25.856	0.194
137	21	-1.968	0.904	-2.072	0.465	25.490	0.456
139	20	+0.712	0.893	-0.705	0.404	24.746	0.391
140	20	-1.252	0.839	-1.133	0.388	25.615	0.360
141	20	-1.464	0.285	-1.528	0.380	25.519	0.186
142	20	-2.613	0.539	-1.793	0.411	25.994	0.235
143	19	-2.626	0.558	-1.854	0.392	25.967	0.318
144	18	-1.490	0.210	-1.795	0.364	25.386	0.159
145	21	-1.980	0.377	-1.535	0.358	25.793	0.288
146	20	-1.569	0.408	-1.827	0.293	25.411	0.218
147	19	-1.736	0.341	-1.645	0.230	25.604	0.136
148	18	-3.065	0.336	-1.783	0.538	26.235	0.315
149	20	-2.741	0.630	-2.075	0.393	25.910	0.369
151	20	-1.701	1.027	-1.119	0.675	25.868	0.249
152	20	-1.737	0.208	-1.379	0.324	25.749	0.146
153	20	-2.548	0.751	-1.350	0.471	26.191	0.322
154	20	-2.961	0.288	-1.738	0.292	26.206	0.234
155	20	-2.214	0.683	-1.804	0.431	25.769	0.480
156	19	-1.607	0.511	-1.587	0.281	25.562	0.312
157	21	+0.909	0.954	-0.552	0.876	24.721	0.356
158	20	-1.144	0.562	-0.699	0.510	25.794	0.262
159	20	-1.162	0.776	-0.691	0.400	25.803	0.456

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
160	20	-2.779	0.385	-1.668	0.416	26.147	0.255
161	21	-2.641	0.886	-1.594	0.401	26.108	0.461
163	19	-1.277	0.296	-0.515	0.233	25.965	0.168
164	20	-0.881	0.186	-0.718	0.269	25.644	0.107
165	20	-2.058	1.000	-1.086	0.632	26.073	0.327
166	20	-2.405	0.241	-1.430	0.393	26.077	0.208
167	20	-1.566	0.707	-1.132	0.485	25.783	0.451
168	19	-0.960	0.235	-0.949	0.379	25.559	0.221
169	20	-1.283	0.219	-1.070	0.326	25.669	0.238
170	20	-0.935	0.159	-1.159	0.273	25.431	0.144
171	21	-1.454	0.400	-0.814	0.323	25.899	0.245
172	20	-1.447	0.453	-1.039	0.305	25.775	0.225
173	20	-0.380	0.227	-0.846	0.356	25.296	0.187
175	16	+1.732	0.436	+0.764	0.428	25.006	0.430
176	20	+0.317	0.346	+0.599	0.400	25.706	0.274
177	21	+0.428	0.383	+0.709	0.400	25.706	0.245
178	20	-0.382	0.186	+0.588	0.326	26.075	0.174
179	20	+0.148	0.671	+0.451	0.504	25.716	0.334
181	19	+1.211	0.886	+1.215	0.686	25.555	0.217
182	20	+1.084	0.150	+1.188	0.339	25.611	0.156
183	20	+0.556	0.510	+1.274	0.449	25.940	0.252
184	19	+0.142	0.253	+0.926	0.419	25.975	0.262
185	20	+0.616	0.170	+0.433	0.367	25.453	0.180
187	20	+0.845	0.719	+1.660	0.841	25.992	0.265
188	20	+0.638	0.242	+0.922	0.443	25.709	0.170
189	20	+0.183	0.410	+1.439	0.385	26.223	0.232
190	20	+0.302	0.348	+1.430	0.543	26.155	0.305

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
191 c	20	+0.898	0.213	+0.960	0.505	25.587	0.242
192 c	20	+1.983	1.237	+1.189	0.785	25.099	0.589
193 c	20	+3.390	1.249	+2.995	0.789	25.329	0.458
194 c	17	+1.498	0.814	+2.070	0.844	25.861	0.315
195	19	+1.046	0.888	+2.530	1.285	26.336	0.450
196	18	+0.543	0.504	+1.775	0.756	26.211	0.238
198	19	+2.804	0.583	+3.141	0.861	25.737	0.173
199	19	+2.757	0.229	+3.053	0.366	25.715	0.169
200	20	+2.735	0.224	+3.430	0.456	25.929	0.158
201	20	+1.946	0.222	+3.202	0.783	26.220	0.393
202	19	+2.042	0.302	+3.036	0.710	26.082	0.409
203	18	+2.720	0.419	+2.730	0.452	25.557	0.317
204	17	+2.915	0.220	+4.184	1.987	26.199	0.962
205	20	+3.023	0.269	+3.337	1.378	25.709	0.664
206	19	+3.051	0.640	+4.677	2.699	26.335	1.499
207	19	+3.062	0.652	+5.094	1.630	26.582	1.078
208	20	+3.043	0.689	+4.083	0.655	26.102	0.532
210	17	+5.088	0.196	+3.851	0.663	24.848	0.476
211	15	+4.662	0.297	+4.411	0.706	25.406	0.532
212	20	+4.712	0.365	+4.753	0.437	25.576	0.199
213	20	+3.015	0.603	+4.365	0.471	26.269	0.388
214	20	+3.668	0.389	+4.692	0.436	26.101	0.293
215	21	+3.534	0.862	+4.286	0.546	25.945	0.647
217	20	+4.867	0.356	+4.637	0.368	25.427	0.206
218	20	+3.684	0.759	+4.878	0.342	26.185	0.481
219	19	+4.089	0.307	+4.728	0.359	25.899	0.170
220	19	+3.935	0.655	+5.374	0.386	26.313	0.442

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
221	19	+5.502	0.294	+5.326	0.705	25.456	0.254
222	20	+5.536	0.254	+5.956	0.332	25.782	0.173
223	20	+5.537	0.291	+6.010	0.594	25.808	0.326
225	20	+4.867	0.407	+6.124	0.356	26.225	0.166
226	19	+4.488	0.733	+5.949	0.492	26.321	0.547
227	21	+5.880	0.332	+6.073	0.855	25.650	0.504
228	21	+6.780	0.662	+5.596	0.442	24.883	0.335
229	20	+6.738	0.591	+7.146	0.411	25.768	0.471
230	20	+6.430	0.594	+7.210	0.499	25.971	0.354
231	20	+5.453	0.591	+7.001	0.283	26.373	0.296
232	20	+5.259	0.647	+7.162	0.369	26.552	0.364
233	19	+6.365	0.897	+7.087	0.521	25.931	0.621
235	18	+7.086	0.266	+7.904	0.374	25.994	0.174
236 d	21	-0.373	0.351	+1.647	0.361	26.615	0.181
237	21	+0.336	0.490	+2.033	0.468	26.450	0.223
238	20	+0.599	0.755	+2.014	0.892	26.290	0.712
239	19	+1.163	0.333	+1.871	0.418	25.934	0.266
240	20	+1.019	0.284	+1.763	0.534	25.955	0.191
241	20	+1.191	0.284	+1.652	0.501	25.803	0.242
242	21	+0.480	0.609	+2.076	0.498	26.395	0.403
244	20	+1.062	0.673	+1.785	0.891	25.926	0.721
245	19	+1.388	0.386	+1.312	0.574	25.509	0.326
246	20	+1.448	0.288	+0.023	0.730	24.744	0.308
247	20	+1.554	0.445	+2.146	0.498	25.872	0.326
248	20	+1.793	0.398	+2.313	0.524	25.836	0.145
249	20	+1.018	0.368	+2.317	0.450	26.246	0.213
250	20	+0.657	0.383	+2.916	0.776	26.733	0.324

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
251	19	+1.637	0.408	+1.743	0.419	25.611	0.225
252	19	+2.460	0.256	+2.611	0.418	25.636	0.153
253	20	+2.088	0.472	+2.947	0.799	26.007	0.542
254	22	+1.749	0.328	+3.300	0.513	26.374	0.311
255	21	+1.749	0.530	+3.210	0.486	26.327	0.347
257	18	+1.649	0.346	+2.551	0.458	26.038	0.212
258	20	+1.956	0.304	+2.666	0.526	25.935	0.298
259	20	+1.473	0.400	+2.094	0.529	25.888	0.253
260	20	+1.339	0.431	+3.314	1.183	26.588	0.428
261	20	+1.269	0.292	+2.940	0.817	26.436	0.314
262	20	+1.201	0.264	+2.082	1.487	26.009	0.735
263	19	+1.135	0.338	+1.224	0.532	25.598	0.370
264	21	+1.950	0.599	+1.122	1.529	25.074	0.688
265	20	+0.929	0.356	+1.768	0.571	26.004	0.250
267	20	+1.383	0.327	+2.988	0.592	26.404	0.180
268	20	+1.335	0.494	+3.750	1.351	26.807	0.464
269	19	+1.541	0.317	+1.853	0.282	25.724	0.137
270	20	+1.654	0.234	+2.085	0.389	25.788	0.138
271	20	+1.716	0.297	+3.538	1.339	26.503	0.618
272	21	+1.334	0.288	+2.526	0.503	26.190	0.175
273	20	+1.605	0.409	+3.592	1.020	26.596	0.348
274	20	+1.690	0.226	+1.979	0.583	25.710	0.260
275	18	+1.530	0.248	+1.775	0.497	25.684	0.317
276	19	+1.509	0.316	+2.131	0.608	25.888	0.298
277	21	+1.651	0.317	+2.291	1.114	25.890	0.530
279	20	+1.927	0.257	+3.949	0.923	26.613	0.372
280	19	+1.513	0.283	+1.640	0.605	25.619	0.362

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
281	19	+1.609	0.339	+0.815	0.530	25.106	0.391
282	20	+1.665	0.273	+1.211	0.753	25.296	0.466
283	19	+1.630	0.223	+2.009	0.590	25.757	0.304
284	19	+1.596	0.351	+3.150	0.990	26.373	0.439
285	20	+1.375	0.299	+2.368	0.648	26.086	0.261
286	20	+1.868	0.301	+3.461	1.334	26.386	0.593
287	18	+1.851	0.273	+1.826	0.417	25.541	0.122
288	20	+1.951	0.325	+1.824	0.560	25.484	0.192
290	20	+1.697	0.265	+2.781	0.487	26.135	0.150
291	20	+1.953	0.332	+3.387	1.186	26.307	0.543
292	20	+1.903	0.312	+2.108	0.542	25.664	0.272
293	18	+1.856	0.275	+1.487	0.329	25.349	0.197
294	20	+1.589	0.318	+2.181	0.625	25.871	0.336
295	19	+1.882	0.210	+2.196	0.363	25.725	0.183
296	19	+1.654	0.258	+3.096	0.631	26.319	0.243
297	20	+1.817	0.255	+3.511	0.941	26.446	0.378
298	18	+1.878	0.271	+2.232	0.354	25.745	0.245
300	20	+2.442	0.399	+2.923	0.689	25.807	0.492
301	23	+2.147	0.309	+2.500	0.877	25.736	0.548
302	19	+2.081	0.509	+3.453	1.996	26.248	1.010
303	19	+1.910	0.384	+3.596	0.831	26.444	0.263
304	19	+1.882	0.423	+3.642	1.726	26.468	0.689
305	19	+1.384	0.242	+1.839	0.311	25.802	0.123
306	20	+1.301	0.216	+1.926	0.305	25.892	0.150
308	20	+1.623	0.333	+2.984	0.785	26.276	0.297
309	20	+1.924	0.307	+3.154	1.424	26.198	0.617
310	19	+1.578	0.316	+2.113	0.587	25.842	0.270

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
311	20	+1.830	0.365	+1.514	0.387	25.380	0.172
312	20	+1.544	0.257	+2.076	0.515	25.840	0.272
313	19	+1.678	0.267	+2.898	1.099	26.198	0.477
314	20	+1.224	0.208	+2.153	0.436	26.053	0.184
315	21	+1.691	0.310	+2.705	1.202	26.084	0.622
316	19	+1.478	0.301	+1.732	0.515	25.690	0.287
317	20	+2.027	0.459	+1.148	0.598	25.061	0.237
318	20	+1.358	0.315	+1.873	0.418	25.831	0.300
319	20	+1.932	0.377	+2.730	1.090	25.975	0.522
320	20	+1.393	0.292	+2.499	0.707	26.144	0.292
321	19	+1.548	0.311	+3.044	0.919	26.345	0.352
322	19	+1.803	0.483	+2.435	1.532	25.883	0.603
323	19	+1.773	0.328	+1.563	0.381	25.439	0.122
324	20	+1.697	0.362	+2.410	1.317	25.925	0.623
325	20	+1.530	0.340	+2.681	0.838	26.167	0.299
326	20	+1.651	0.348	+2.867	0.959	26.200	0.354
327	19	+2.132	0.275	+2.576	1.434	25.778	0.689
328	19	+1.657	0.428	+1.779	0.569	25.616	0.373
329	20	+1.918	0.238	+1.381	0.447	25.254	0.298
330	18	+1.633	0.379	+2.154	0.550	25.833	0.332
331	20	+2.013	0.349	+3.517	1.171	26.344	0.524
332	20	+1.488	0.256	+2.573	0.413	26.135	0.189
333	20	+1.874	0.392	+3.061	1.382	26.175	0.618
334	19	+1.692	0.372	+2.073	0.483	25.759	0.295
335	20	+2.031	0.283	+1.511	0.373	25.266	0.184
336	20	+1.662	0.406	+2.303	0.551	25.898	0.297
337	20	+2.076	0.383	+3.390	1.381	26.243	0.578

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
338	20	+2.330	0.318	+3.668	0.596	26.263	0.370
339	20	+2.714	0.312	+5.191	0.829	26.842	0.305
340	19	+2.484	0.342	+2.963	0.505	25.813	0.207
341	20	+2.482	0.355	+3.174	0.506	25.928	0.132
342	20	+2.844	0.356	+4.699	1.554	26.519	0.631
343	19	+2.269	0.301	+3.636	0.714	26.281	0.255
344	20	+2.462	0.345	+4.395	1.016	26.568	0.357
345	20	+2.280	0.344	+2.751	0.388	25.809	0.234
346	19	+2.750	0.389	+2.379	0.390	25.347	0.269
347	20	+2.809	0.328	+2.885	0.653	25.588	0.460
348	20	+2.598	0.283	+3.083	0.447	25.815	0.270
349	20	+2.136	0.455	+3.874	1.213	26.467	0.426
350	20	+2.073	0.347	+3.533	0.865	26.327	0.307
351	20	+2.419	0.289	+2.808	0.978	25.757	0.510
352	19	+2.433	0.255	+2.458	0.733	25.563	0.381
353	20	+2.564	0.254	+2.301	0.442	25.407	0.303
354	19	+2.393	0.296	+2.767	0.482	25.756	0.264
355	19	+2.741	0.304	+3.790	0.635	26.112	0.373
356	19	+2.353	0.201	+3.254	0.462	26.038	0.185
357	19	+2.730	0.300	+4.487	1.058	26.474	0.506
358	19	+3.231	0.190	+3.245	0.330	25.562	0.130
359	20	+3.248	0.178	+3.258	0.222	25.560	0.094
360	20	+3.018	0.329	+4.587	0.979	26.378	0.489
362	19	+2.773	0.343	+4.342	1.293	26.375	0.569
363	20	+2.720	0.386	+2.886	0.393	25.641	0.357
364 e	19	-0.756	1.672	-1.529	2.220	25.119	0.347
365	19	+0.522	2.218	+0.791	3.042	25.692	0.493

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
366	20	+2.254	0.927	+2.617	1.092	25.750	0.229
367	20	+1.893	0.963	+3.494	1.487	26.398	0.398
368	20	+1.788	1.285	+3.420	0.887	26.414	0.388
369	16	-0.274	1.826	+0.220	2.358	25.817	0.402
370	13	+0.901	2.143	+0.961	2.630	25.583	0.354
371	12	-1.550	1.389	-1.323	1.954	25.675	0.318
372	14	-0.620	1.844	-0.339	2.027	25.707	0.177
373	15	+0.908	1.741	+2.551	1.910	26.418	0.443
374	12	+1.614	1.014	+3.097	1.527	26.339	0.306
375	16	+1.366	2.321	+2.870	3.541	26.327	0.859
376	12	-2.247	0.238	-1.872	0.245	25.758	0.067
377	14	-2.125	0.256	-1.507	0.304	25.889	0.125
378	19	+1.072	1.682	+3.523	1.774	26.825	0.465
379	19	-0.406	0.996	+0.880	1.099	26.239	0.228
380	20	+1.351	2.361	+3.023	3.579	26.424	0.654
381	16	-1.499	0.601	-1.019	0.705	25.812	0.307
382	17	+0.666	1.180	-0.125	1.092	25.111	0.251
383	18	-1.857	0.933	-1.188	0.733	25.913	0.296
384	19	+1.401	1.888	+2.587	3.003	26.171	0.699
385	17	-1.756	1.078	-0.625	1.518	26.158	0.251
386	16	-0.069	2.021	+1.752	2.753	26.504	0.563
387	14	-0.155	1.546	-0.003	1.221	25.635	0.273
388	12	-0.448	1.133	-0.650	0.955	25.443	0.201
389	19	-0.541	0.556	+0.053	0.507	25.874	0.212
390	18	+1.056	1.279	+1.502	1.660	25.788	0.483
391	19	-1.199	1.186	-0.086	1.565	26.148	0.271
392	20	-2.345	0.712	-0.699	0.532	26.422	0.354

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
393	18	+0.744	1.283	+1.549	1.226	25.973	0.648
394	14	+1.408	0.250	+1.274	0.324	25.480	0.149
395	13	+0.437	1.578	+1.023	1.020	25.861	0.558
396	18	-1.266	0.858	+0.102	1.124	26.278	0.371
397	18	-1.055	0.428	-0.094	0.460	26.068	0.277
398	17	+2.387	1.952	+2.683	0.995	25.702	0.612
399	14	+0.368	1.712	+0.567	1.145	25.659	0.359
400	15	+3.538	0.223	+2.394	0.647	24.907	0.317
401	16	+0.446	1.626	+1.049	1.249	25.879	0.235
402	15	+1.353	2.447	+2.260	1.337	26.027	0.640
403	20	-0.182	1.167	+0.693	1.008	26.024	0.193
404	20	-0.468	2.294	+1.225	1.374	26.437	0.617
405	18	+2.014	2.258	+2.394	1.726	25.758	0.312
406	14	+1.652	1.304	+1.761	1.139	25.614	0.162
407	18	+1.124	2.246	+1.705	1.862	25.867	0.235
408	20	+1.658	2.428	+2.765	1.469	26.134	0.610
409	16	-0.386	1.080	+0.655	1.070	26.112	0.154
410	17	-0.907	0.542	+1.555	0.812	26.832	0.411
411	14	+2.032	1.234	+2.377	0.994	25.741	0.167
412	14	+3.631	0.426	+4.005	0.450	25.758	0.105
413	17	+2.667	2.087	+3.939	0.998	26.220	0.604
414	16	-0.934	0.276	+0.906	0.567	26.522	0.307
415	19	-0.419	1.317	+1.226	0.871	26.422	0.339
416	18	+2.738	1.851	+3.321	1.005	25.859	0.548
417	15	+2.197	2.320	+2.303	1.456	25.603	0.523
418	12	+1.016	1.667	+0.654	1.654	25.346	0.496
419	19	+1.634	2.368	+2.431	1.828	25.980	0.338

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
420	18	-0.783	1.362	+0.853	1.296	26.414	0.433
421	16	+3.450	0.406	+4.616	0.448	26.176	0.244
422	17	+0.968	1.738	+1.921	0.892	26.051	0.654
423	12	+0.193	1.948	+0.850	2.204	25.908	0.262
424	18	-0.188	1.710	+0.452	2.053	25.898	0.258
425	18	+0.143	1.620	+0.503	2.077	25.747	0.317
426	15	+0.191	2.311	+1.870	2.438	26.433	0.524
427	20	-2.093	0.298	-1.280	0.357	25.991	0.208
428	18	+0.368	1.836	+1.895	2.370	26.351	0.621
429	17	-1.834	0.222	-1.865	0.384	25.537	0.136
430	14	-1.695	0.229	-1.760	0.271	25.519	0.138
433 f	15	-0.503	1.496	+2.243	1.208	26.975	0.268
434	16	+3.037	1.785	+3.584	0.832	25.839	0.554
435	12	+2.756	1.266	+2.309	1.379	25.302	0.400
436	17	+2.306	2.742	+3.170	1.642	25.998	0.771
437	16	+4.237	0.360	+4.550	0.471	25.724	0.191
438	16	+2.050	1.193	+4.036	1.657	26.590	0.504
439	19	+1.282	1.232	+2.483	1.142	26.194	0.254
440	18	+3.658	1.226	+4.513	0.721	25.998	0.687
441	12	+2.820	2.064	+3.268	1.796	25.795	0.286
442	10	+1.469	0.934	+2.298	1.103	26.000	0.185
443	14	+4.809	0.286	+5.163	0.382	25.745	0.257
444	15	+3.023	2.273	+4.760	2.631	26.467	0.413
445	16	+2.492	1.566	+3.962	1.063	26.331	0.366
446	15	+4.634	1.013	+6.248	2.180	26.388	0.786
447	4	+4.911	0.131	+5.929	0.231	26.100	0.158
448	6	+4.117	0.443	+5.189	0.463	26.128	0.121

Table 1: TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
449	13	+2.985	1.509	+4.704	1.211	26.460	0.308
450	13	+2.184	1.921	+3.511	1.364	26.255	0.448
451	13	+4.562	1.413	+5.730	0.831	26.168	0.551
452	12	+4.150	1.490	+4.896	1.302	25.955	0.256
453	11	+5.365	0.293	+3.922	0.860	24.729	0.465
454	18	+4.915	1.352	+4.939	0.961	25.557	0.542
455	17	+4.700	2.097	+5.026	1.052	25.714	0.705
456	20	+3.582	1.950	+4.734	1.269	26.165	0.417
457	17	+4.712	1.501	+6.885	1.208	26.690	0.308
458	19	+5.786	1.043	+5.109	0.459	25.172	0.413
459	11	+5.554	0.348	+5.793	0.213	25.685	0.160
460	15	+5.797	0.366	+5.657	0.670	25.470	0.457
461	17	+5.987	0.282	+5.495	0.518	25.280	0.241
462	19	+5.174	0.372	+5.682	0.564	25.825	0.382
463	14	+4.543	1.090	+5.957	0.777	26.303	0.352
464	17	+5.733	0.912	+5.800	0.597	25.585	0.420
465	15	+6.077	0.222	+5.807	0.303	25.405	0.118

Notes:

a - Late part of cycle 117 and most of cycle 118 lost because of TOPEX SafeHold/PowerOff condition . Power was restored to the altimeter late in cycle 118, but remaining cycle 118 calibrations were removed from our analysis data set to allow altimeter temperatures to stabilize.

b - SafeHold/PowerOff during cycle 123; then both calibrations on 1996 day 023 were edited out of the altimeter data to allow altimeter temperatures to stabilize after power was restored.

c - Temperature-corrected delta ranges and their standard deviations for

cycles 192 through 194 were entered incorrectly in the table update of January 8, 1998. This error was discovered by Mark Guman, JPL, and the correct table values were entered on January 15, 1998.

d - Cycle 235 was the last TOPEX cycle using Side A of the altimeter. All data from the start of cycle 236 are taken with the TOPEX altimeter's Side B. The users of these data should be warned that as of June 1999 the calibration of Side B relative to Side A is not yet completed. Be very careful about mixing Side B and Side A data!

e - Early in cycle 364 the calibration mode combined delta range began to exhibit a "toggling" behavior having an amplitude of about 5 mm. This toggling appeared in the Ku-band calibration range results only, while the C-band calibration ranges showed no such toggling. Similar behavior had been seen in some of the TOPEX altimeter's preflight thermal/vacuum testing. Once the toggling began, in cycle 364, it has continued to the present time. We believe this to be the result of gradual aging of some Ku-band altimeter components which allowed the altimeter to drift into a region of toggling behavior, and we do not feel that there should be any concern about this behavior. The calibration mode variations are still well below one centimeter.

f - Cycle averages for cycles 431 and 432 are not provided; most of the data in these two cycles were missing because of a TOPEX SafeHold/PowerOff condition which resulted from problems with the satellite's reaction wheels.

Data from Table 1 are plotted in the following three figures.

Figure 1 plots the combined delta range with NO temperature correction.

**Figure 1. Combined (Ku&C) Delta Range vs. Cycle
NOT corrected for UCFM temperature**

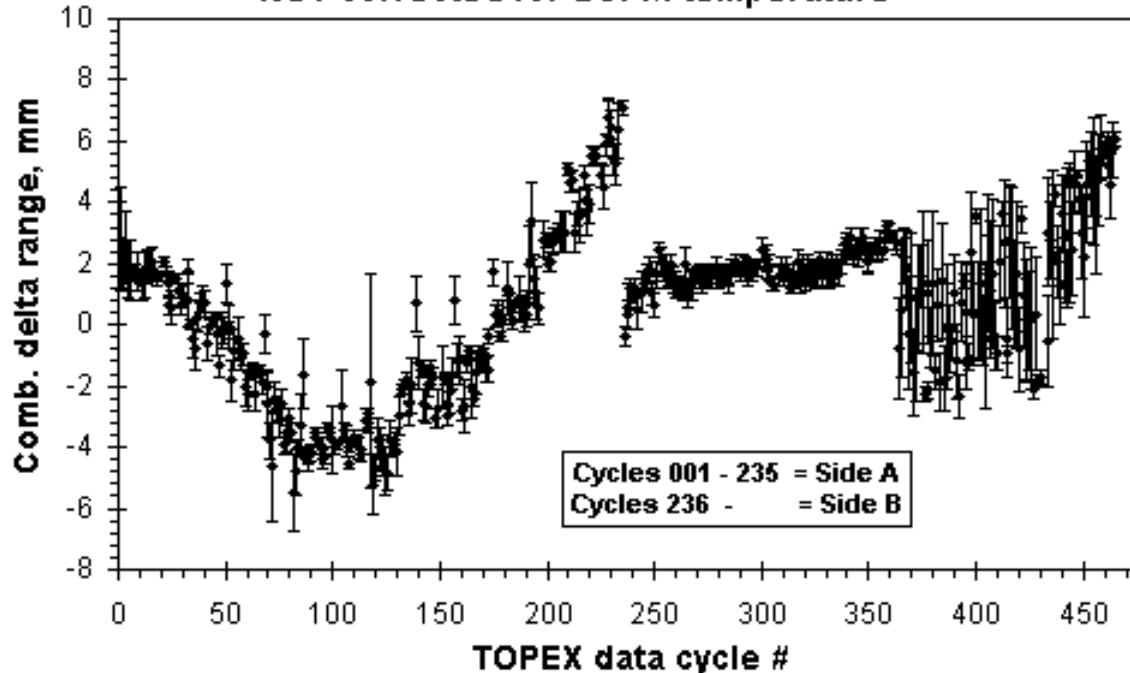


Figure 2 is the plot of the combined delta range WITH temperature correction.

**Figure 2. Combined (Ku&C) Delta Range vs. Cycle
WITH UCFM temperature correction**

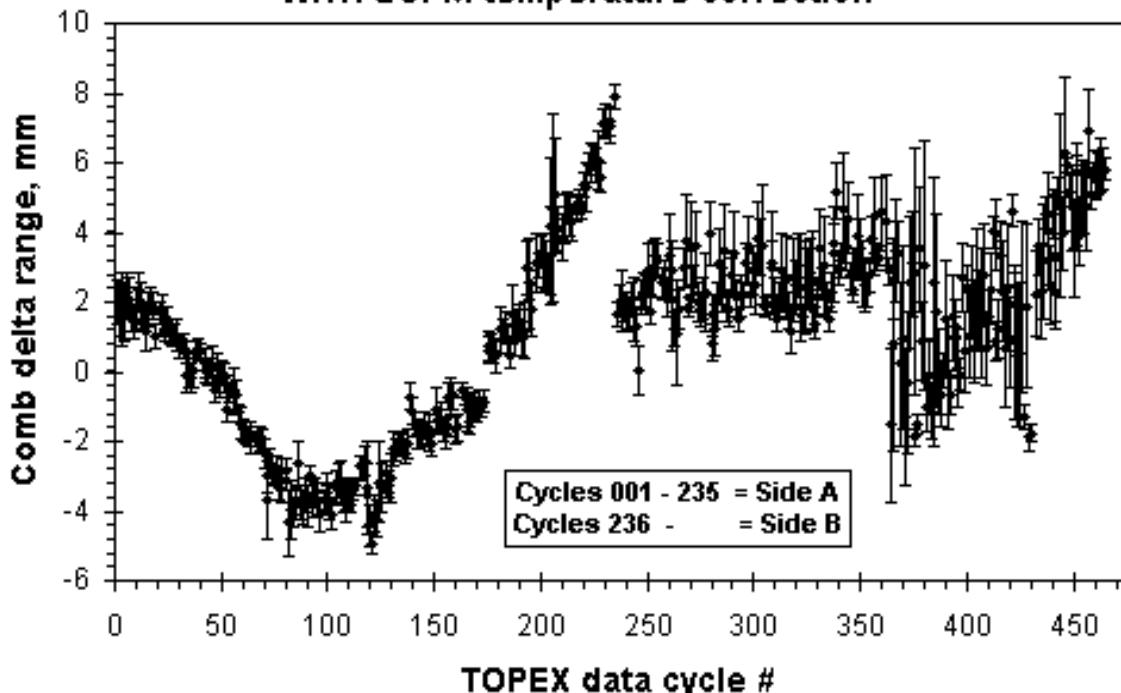


Figure 3 plots the UCFM temperature.

